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ANALYSIS OF STUDENTS' ERRORS OF CLASS VIII MTs ATH-THOHIRIYYAH IN SOLVING CIRCLE MATERIAL PROBLEMS BASED ON NOLTING THEORY

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Abstrak

Penelitian ini merupakan penelitian deskriptif kualitatif yang bertujuan untuk mendeskripsikan jenis-jenis kesalahan siswa dan faktor-faktor yang menyebabkan siswa melakukan kesalahan dalam menyelesaikan soal-soal materi lingkaran berdasarkan teori Nolting. Penelitian ini melibatkan 25 siswa kelas VIII B MTs Ath-Thohiriyyah Watusalam tahun ajaran 2021/2022 melalui metode tes dan wawancara. Hasil penelitian menunjukkan jenis kesalahan siswa adalah: 65,6% kesalahan konsep, 63,2% kesalahan mengerjakan tes, 57,6% kesalahan salah baca, 56% kesalahan ceroboh, 8% kesalahan belajar, dan 6,4% kesalahan aplikasi. Faktor-faktor yang menyebabkan siswa melakukan kesalahan karena gugup, tidak memahami soal, tidak belajar sebelum mengerjakan tes, tidak teliti, tidak mengecek kembali jawaban sebelum dikumpulkan, tidak memahami rumus, tidak memahami langkah pengoperasian, tidak menyukai matematika, dan kebiasaan belajar dengan membaca sekilas tanpa pemahaman.
Kata kunci: Analisis Kesalahan; Lingkaran; Teori Nolting

Abstract

This research is a qualitative descriptive research that aims to describe the types of student errors and the factors that cause students making mistakes in solving problems about circle material based on Nolting's theory. This research involved 25 students of class VIII B MTs Ath-Thohiriyyah Watusalam for the academic year 2021/2022 through test and interview methods. The results showed the types of student errors were: 65.6% concept errors, 63.2% test-taking errors, 57.6% misread-directions errors, 56% careless errors, 8% study errors, and 6.4% application errors. Factors that cause students making mistakes because of they are nervous, don't understand the questions, don't study before doing the test, don't take care, don't recheck the answers before they are collected, don't understand the formula, don't understand the operating steps, dislike mathematics, and study habits by skimming. without understanding.
Keywords: Error Analysis; Circle; Nolting Theory

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INTRODUCTION

Mathematics is one of the sciences that students need to master. This is because mathematics is a means of solving problems in everyday life. Sukmawati & Amelia (2020) stated that mathematics is important because it can equip students with the ability to think logically, analytically, systematically, critically, and creatively as well as the ability to work together. However, in reality, students cannot apply mathematics with these abilities. This is because most students consider mathematics as a subject containing formulas to count and memorize. Therefore, it is not uncommon for students to feel bored, uninterested in learning mathematics, and have difficulty understanding the material, especially solving problems.

Difficulties in solving math problems are also experienced by students at MTs Ath-thohiriyyah. However, most students find it difficult to communicate their understanding, including low courage to ask questions when they don't understand. Based on the results of interviews with the mathematics teacher of class VIII MTs Ath-thohiriyyah, the mistakes that many students make when working on problems lie in the circle material. In learning mathematics including circle material, students have not been able to apply formulas and students find it difficult to remember the concepts that have been conveyed by the teacher. The error is because the ability to understand mathematical concepts of students is still low. This is in line with Yadrika, et al. (Saifanah & Zanthy, 2020) that student learning outcomes in circle material are still low when compared to other materials.

According to Ningsih, et al. (2019), a circle is a collection of points that have the same distance to a certain point called the circle's center point. The number of discussions and formulas in circles causes students to not understand the material well. Nevertheless, circle material is important for students because it can help develop students' mathematical abilities, especially in solving problems in everyday life. Students' lack of interest in circle material is one of the causes of students making mistakes in solving circle material problems.

Based on the answers to the odd semester final assessment, many students make mistakes marked by learning outcomes that are still below the minimum completeness criteria (KKM). As many as 85% still scored below the KKM. When students are given one of the math problems for the odd semester final assessment, "The price of 2 pairs of shoes and 3 pairs of sandals is Rp600,000, while the price of 3 pairs of shoes and 4 pairs of sandals is Rp860,000. How much is one pair of shoes and 2 pairs of sandals?". Here are the answer of the student representatives.

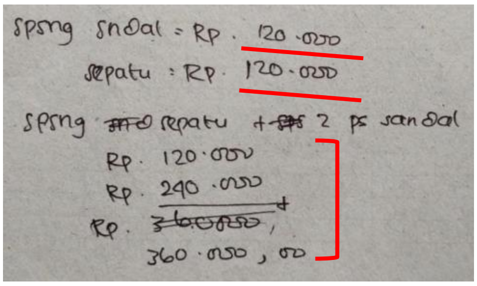


Figure 1. Student Work Results

Based on the answers above, the mistake the student made was that the student didn't write what is known and asked. In the problem, students are asked to find the price of a pair of shoes and two pairs of slippers. The student's answer shows that the student doesn't understand the concept. This can be seen because students don't write clear formulas or concepts. The unclear formula used results in the procedure of the calculation is also incorrect.

The number of errors made by students needs attention to be followed up. Therefore, it is necessary to analyze the mistakes made by students so that these errors aren't repeated. Analysis of students' errors in solving mathematics problems is important, especially circle material. Errors made by students can be used to determine learning difficulties and the level of understanding of students as an effort to improve mathematics learning. In line with the opinion of Riantini, et al. (2020) that error analysis can provide a good picture of why students have difficulty learning mathematics and can show students' understanding of concepts.

The analysis of student errors in solving the circle material problems is in line with research conducted by Riantini, et al. (2020) on the analysis of student errors in circle material based on Watson's error category. The results revealed that in solving the five problems given, students made several mistakes. These errors include comprehension, transformation, process skills, and coding errors. Factors that cause it because students were less focused in working on questions, lacked understanding of the elements and formulas of circles, and don't have a strong motivation to solve the problems given.

In addition, there is research conducted by Sanaky (2020) on analyzing student errors in solving circle problems in class VIII students of SMP Muhammadiyah Ambon. The conclusions of the research showed that students made (1) factual errors because they wrote the wrong mathematical symbols, (2) conceptual errors because they used the wrong concepts or did not know the meaning of the problem, and (3) principle errors because they wrote the formula for the area of a circle incorrectly. The results of the above research above are different from what the researchers will do and this research has not provided various alternative solutions for some of the errors that occur so this research is still worth doing.

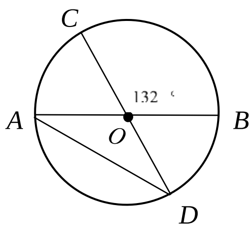
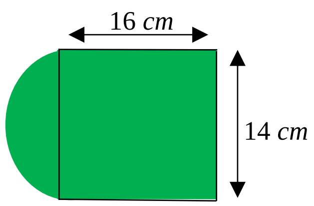
According to Nolting (in Ulpa, et al., 2021), there are six types of student errors in solving problems: misread-direction errors, careless errors, concept errors, application errors, test-taking errors, and study errors. According to Ulpa, et al. (2021), this type of error in Nolting's theory emphasizes more on the analysis of concept errors. Furthermore, reviewing concept errors can improve understanding and learning achievement. Therefore, this study uses Nolting's theory in analyzing student errors. Based on this description, this research is entitled "Analysis of Student's Errors of Class VIII Mts Ath-Thohiriyyah in Solving Circle Material Problems Based On Nolting Theory". The purpose of this research is to describe the types of student errors in solving circle material problems based on Nolting's theory. In addition, to find out the factors that cause students to make mistakes.

METHOD

This research is qualitative descriptive research. This research aims to describe the types of errors based on Nolting's theory and the factor that cause student to make mistakes in solving circle material problems. The research subjects were carried out in class VIII B of MTs Ath-Thohiriyyah Watusalam in the 2021/2022 academic year with a total of 25 students.

The method of data collection was obtained from written test results and interviews. Written tests were used to determine the types of student errors based on Nolting's theory. The test was a description test with five items of circle material questions and one additional question to find out the types of student errors. The following test instrument consists of five items of circle material and one question to find out learning mistakes.

Table 1. Circle Material Test Instrument

No.	Questions
1.	 In the circle beside, it is known $\angle BOC = 132^\circ$. How many degrees of $\angle ADC$?
2.	 Based on the picture beside, determine the area of the shaded region!
3.	The radius of the two circles is 7 *cm* and 5 *cm*, respectively. If the distance between the two centers is 20 *cm*, then what is the length of the tangent of the inner circle?
4.	*A* is the center of a circle whose radius is 10 *cm* and *B* is the center of a circle whose radius is 5 *cm*. The distance between the two centers is 13 *cm*. Find the length of the tangent to the external tangent of the two circles!
5.	Two circles have a radius of 12 *cm* and 4 *cm*, respectively. If the length of the tangent to the outer tangent of the two circles is 15 *cm*, find determine the distance between the two centers of the circles!
6.	How do you prepare for the test? (Can choose or write more than one answer) a. Study before the test

b. Make a habit of repeating the material

c. Make a habit of practicing problems

d. Others, ……………… (please list)

Meanwhile, interviews were conducted to find out the factors that caused the student to make mistakes. Interviews were conducted with six subjects: two subjects of high ability, two subjects of medium ability, and two subjects of low ability. The results of grouping student abilities based on the scores obtained from the test results are as follows.

Table 2. Student Ability Grouping

Score	Group	Total Students
$n \geq 75$	High	4
$37 < n < 75$	Medium	17
$n < 37$	Low	4

Data analysis in this study was carried out after the data was collected. Furthermore, it is presented in the form of descriptive data. Analysis activities were carried out based on the Miles and Huberman model. Data analysis steps according to the Miles and Huberman model (Anggito & Setiawan, 2018) consist of data reduction, data presentation, conclusion drawing or verification. The indicators used to analyze and describe the types of student errors in solving circle material according to Ulpa, et al. (2021) and Rahmatia (2021) are shown in Table 3 below.

Table 3. Error Type Indicator Based on Nolting's Theory

Error Type	Indicator
Misread-direction Errors	1. Students don't understand the information in the problem 2. Students don't write the known and questionable components of the problem
Careless Errors	1. Students are careless when working on problems (incorrectly writing units, symbols, or lack of accuracy in arithmetic operations)
Concept Errors	1. Students don't know the concepts needed to solve the problem 2. Students don't know the formula to be used in solving the problem

Application Errors	1. Students know the circle formulas but are unable to apply them to solve the problem
Test-taking Errors	1. Students leave answers blank without writing anything 2. Students are unable to complete the answer to the end 3. Students aren't able to conclude the final result
Study Errors	1. Students don't spend enough time learning the material 2. Students rarely solve practice problems

For the data in this research to be more accountable as research, data validity tests were carried out. The validity test is triangulation. This research uses triangulation techniques are different data collection techniques to get data from the same source simultaneously. (Anggito & Setiawan, 2018).

RESULT AND DISCUSSION

Data analysis was carried out through the results of student work that had been collected. Each student who makes a mistake on each item is analyzed for the form of error and classified into the type of error according to Nolting's theory. The following is a description of the forms of errors made by students based on Nolting's theory.

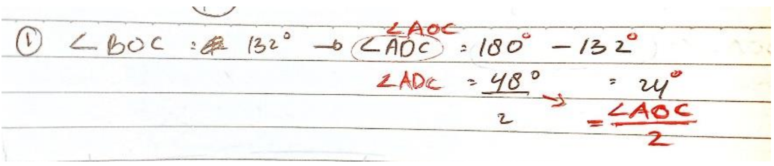


Figure 2. Answer to Question Number 1

Figure 1, shows that the student's answer has misread-direction errors, concept errors, careless errors, and test-taking errors. Misread-direction errors are characterized by students not writing what is known and asking for the problem. Furthermore, in the solution step, to determine the size of the *ADC* angle, students do not write the formula first. Students immediately write the calculation without a clear formula. This shows that students make concept errors. Students should find the central angle of *AOC* first, then find the perimeter angle of *ADC*. Careless errors are shown by students not writing the degree symbol on the number that shows the size of the angle, as 180 – 132 should be $180^\circ - 132^\circ$. Test-taking errors can be seen from the student not being able to write the final result that has been obtained with a conclusion sentence.

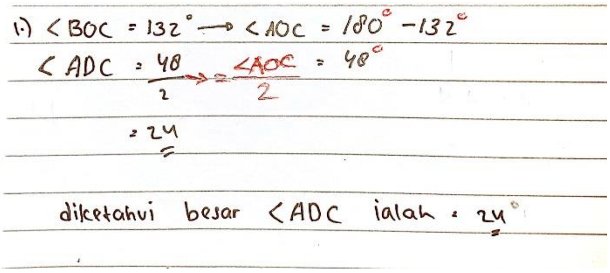


Figure 3. Answer to Question Number 1

Based on Figure 2, it can be seen that students do not first write down what is known and asked from problem number 1. Therefore, the student's error is in the form of misread-direction errors. In addition, Figure 2 shows that students can solve the problem with the correct solution steps. However, students do not first write the formula before doing the calculation. This is included in concept errors. Furthermore, in the solution step, students do not include the degree symbol in the number that shows the angle size. Such student errors include careless errors.

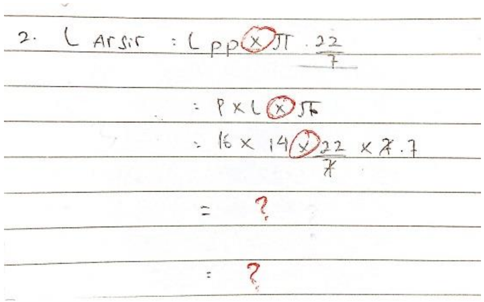


Figure 4. Answer to Question Number 2

In Figure 3, it can be seen that the student made misread-direction errors. Misread-direction errors are characterized by not writing what is known and asking for the problem. In addition to misread-direction errors, other errors are in the form of concept errors. Students do not understand the solution to the problem. This can be seen from the work in the first step that students are not correct when writing formulas or modeling mathematics. Students are wrong when using multiplication operations to calculate the entire area of the rectangle and semicircle. Students are also unable to write the circle formula correctly. Furthermore, in the calculation procedure, students do not complete the steps until the end. Therefore, students are also unable to write the conclusion of the final result of solving the problem. Such errors are included in test-taking errors.

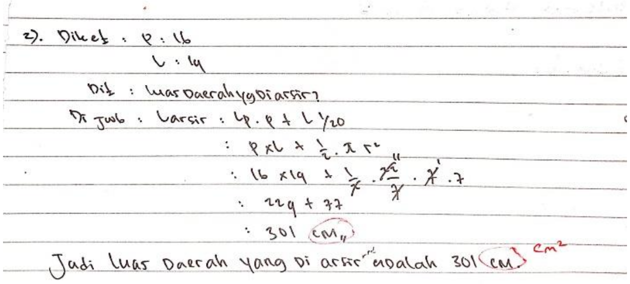


Figure 5. Answer to Question Number 2

In Figure 4, it can be seen that students can write what is known and ask from the problem. In addition, students are also able to solve the problem well. However, when writing units, students experience carelessness in writing units. Students write *cm* to show the unit of area. It should be cm^2 to show the unit of area. This shows that students make careless errors.

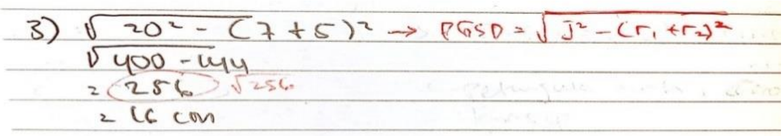


Figure 6. Answer to Question Number 3

Figure 5 shows that students made mistakes during the test in the form of not writing the conclusion of the solution process. In addition to this error, the student did not write down what information was known and asked about the problem. Such errors are called misread-direction errors. Figure 5 also shows careless errors. The student did not write back the root sign in the third step of the work, even though the number was not yet a root result.

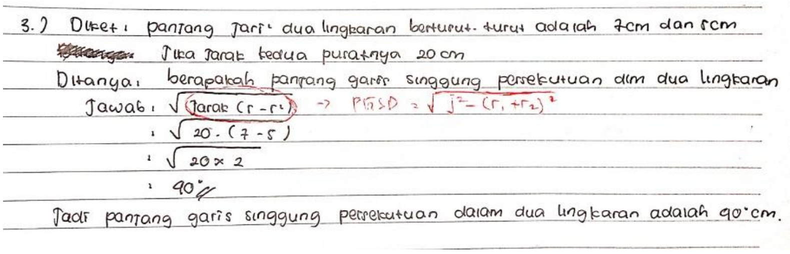


Figure 7. Answer to Question Number 3

Figure 6 shows that students already know the instructions of the problem by writing what is known and asked. In addition, students write the conclusion of the solution process. However, when answering the question, students cannot use the concept correctly. The student wrote the wrong formula. Errors made by students like this include concept errors. This also makes students operate numbers incorrectly. The resulting conclusion is also incorrect. The incorrect conclusion includes test-taking errors.

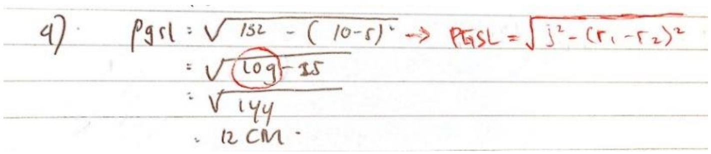


Figure 8. Answer to Question Number 4

Figure 7 shows that the student did not write down what was known and what was asked. These errors include misread-direction errors. In addition, students also make concept errors. Where students do not write down what kind of formula is used first. The formula that should be included is $PGSL = \sqrt{jarak^2 - (r_1 - r_2)^2}$. When viewed further from the completion step, the student was able to solve the problem with the correct steps. Furthermore, in the last step, students do not conclude the final results obtained. The error of not being able to conclude is a test-taking error.

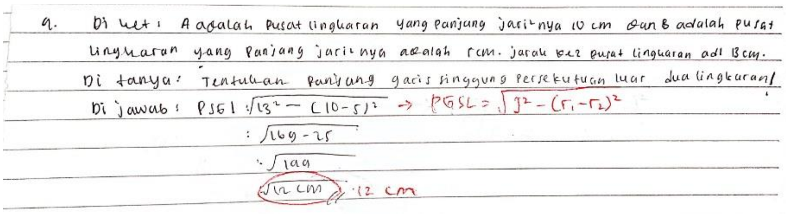


Figure 9. Answer to Question Number 4

In Figure 8, it can be seen that the student made careless errors. The student's carelessness is shown in the final result. The student tried to operate the root of 144 but still wrote the root symbol at the number 12. Where the number 12 is already the final result so there should be no need to write the root symbol again. The student's work also shows concept errors. The student did not write the formula first even though the student was able to operate the solution steps.

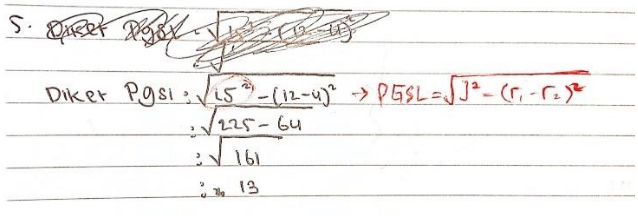


Figure 10. Answer to Question Number 5

Figure 9, shows that students make misread-direction errors, students do not include what is known and asked based on the problem. Students also make concept errors, students do not write the formula used before substituting numbers. In addition, it appears that students already know that the formula used is the formula for the tangent line of the outer fellowship of two circles, but students incorrectly substitute the numbers according to the formula. Therefore, the error is an application error. As for the final step, the student did not conclude the final result of the solution process that had been done. This includes errors during the test.

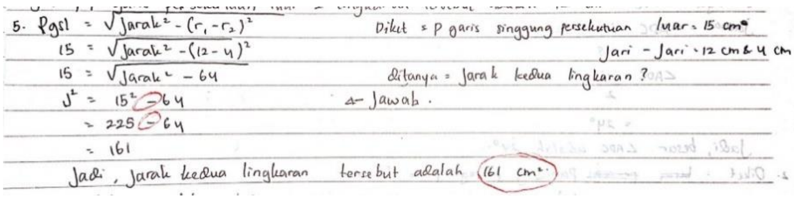


Figure 11. Answer to Question Number 5

Figure 10 shows that in the completion step when students move the distance and length of the tangent line of the outer circumference of two circles, the calculation operation used does not change. They should have used the addition operation. Therefore, the conclusion made was wrong. The conclusion error was an error during the test. When the student tried to conclude the final result, the unit used was cm^2, which should have been cm. This is a careless error. Students are careless in the use of distance units.

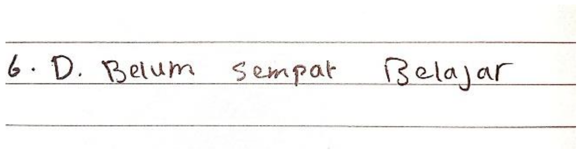


Figure 12. Answer to Question Number 6

Figure 11 shows that a small number of students have not taken the time to study. A total of 2 students wrote statements that they had not had time to study in facing the test on the circle material. This shows that in the 5 items of circle material there are also learning errors.

Based on the test results that have been analyzed, it can be seen that students' errors in solving problems on circle material. The following is the percentage of each type of error according to Nolting's theory.

Table 4. Percentage of Student Error Types Based on Nolting Theory

Question Number	Mi	Ca	Co	Ap	Te	St
1	9	23	25	0	9	2
2	18	14	6	0	14	2
3	15	15	9	0	17	2
4	14	11	20	0	14	2
5	16	7	22	8	25	2
Total	72	70	82	8	79	10
Percentage	57,65%	56%	65,6%	6,4%	63,2%	8%

Description:

Mi: *Misread-directions errors*

Ca: *Careless errors*

Co: *Concept errors*

Ap: *Application errors*

Te: *Test-taking errors*

St: *Study errors*

Table 1 shows that students made errors in all types of errors according to Nolting's theory. In addition to knowing the types of student errors, this research is also to find out the factors that cause students to make mistakes.

In concept errors with the highest percentage of errors of 65.6%, students made mistakes in the form of students using the wrong concept, not writing formulas, and not using formulas correctly. Based on the results of the interview, student errors are due to students not being accustomed to writing formulas, being nervous, not being careful, not understanding the concept but being embarrassed to ask, not understanding the problem, and not studying before the test. This is by Saifanah & Zanthy (2020) that concept errors are caused by not mastering the concept of circle material and not being careful in working on problems. In addition, it is also reinforced by Sanaky's research (2020) that concept errors in circle material are due to students not knowing the masked off the question.

The next type of error is test-taking errors with a percentage of 63.2%. This error is known from leaving the answer blank, not completing the process to the end, and incorrectly concluding the final result, not writing the conclusion. Based on the results of the interview, the factors that cause test-taking errors are that students do not understand the operation correctly, are not used to writing conclusions, and do not study before the test. In line with the results of research by Ulpa, et al. (2021) which states that errors during the test are caused by not being accustomed to writing conclusions.

Another type of student error is misread-direction errors with a percentage of 57.6%. Misread-direction errors are made by students in the form of students not writing the information known and asking for the problem completely and accurately. Based on the results of the interview, this is because students are nervous, do not understand the information from the problem, are not familiar with writing is known and asked, low ability to identify from pictures, and do not study before the test. This is supported by Fathiyah's research (2020) that misread-direction errors are caused by students not being able to mention the known and questioned components of the problem, and not being able to read the information in the picture shown in the problem.

Furthermore, there are types of errors made by students in the form of careless errors with a percentage of 56%. Careless mistakes made by students were in the form of students not writing the degree symbol, writing the wrong unit, not writing the unit, writing the wrong calculation operation, miscalculating, not writing the root symbol, writing the root symbol on the rooting number, putting the square wrong, and not writing the square. Based on the results of the interview, it was because students forgot to write the right symbol or unit, were less careful, were nervous, and students did not recheck the answers before submitting them. In line with Swan (Fathurrohmah et al., 2021) that human error is due to nervous thinking and lack of concentration.

There are other types of study errors that students also make. The percentage of study errors is 8%. Learning errors made by students in the form of students not preparing themselves to take the test by learning circle material. Based on the results of the interview, it is because students do not like math and learning habits of only skimming without understanding the material. In line with Ulpa, et al. (2021) students rarely practice problems and do not deepen the material.

The last type of error is application errors of 6.4%. The form of application error is that students incorrectly substitute numbers according to the formula. Based on the results of the interview, the factor causing students to make these mistakes is that students only memorize the formula without knowing the meaning of the formula. This is reinforced by Sukmawati & Amelia's research (2020) that student errors are caused because students cannot apply the formula.

Based on the description of the types of errors and factors that cause students to make mistakes above, there are several solutions to minimize this, namely:

1. The solution to minimize misread-direction errors, students should be able to manage the work of the problem to get used to practicing problems including image-based problems to develop the ability to understand information from the problem.
2. To minimize careless errors, students should double-check their answers before submitting them to the teacher.
3. The solution to minimize concept errors, students should have the courage to ask the teacher if they find concepts that are not yet understood, and get used to doing practice problems accompanied by writing formulas. In addition, teachers

can implement interactive learning so that students are actively involved, including having the courage to ask questions. Teachers can also provide an understanding to students that students who ask questions don't mean that they can't understand.

4. The solution to minimizing test-taking errors, students should master the concept of arithmetic operations and get used to writing conclusions at the end of the answer.
5. To minimize application errors, students should deepen their understanding of formulas. Meanwhile, teachers can emphasize understanding the concept of the material taught in addition to memorizing the formula and train students by giving non-routine problems.
6. To minimize study errors, students should practice problems with various types and levels, eliminate the assumption that mathematics is a difficult subject to understand, make a habit of repeating material after learning, and take the time to study before the test.

CONCLUSION

Based on the result of the analysis above, students made six types of errors based on Nolting's theory in solving circle material problems. First, conceptual errors amounted to 65.6%, the reason was that students are not used to writing formulas, are nervous, don't take care, don't understand the concept but are embarrassed to ask, don't understand the problem, and don't study before the test. Second, test-taking errors amounted to 63.2%, the reason was that students don't understand the operation steps correctly, are not used to writing conclusions, and don't study before the test. Third, misread-direction errors amounted to 57.6%, the reason was that students are nervous, don't understand the information, don't use the writing known and asked, low ability to identify information images, and don't study before the test. Fourth, careless errors amounted to 56%, the cause was that students forgot to write units or symbols, don't take care, and don't recheck the answers before they are collected. Fifth, study errors by 8%, the cause was that students dislike mathematics and study habits by skimming without understanding the material. Sixth, application errors of 6.4%, the reason was that students only memorize the formula without knowing the meaning of the formula.

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